Individuals with internet gaming disorder have similar neurocognitive impairments and social cognitive dysfunctions as methamphetamine-dependent patients

Las personas con trastorno de juego en Internet tienen deficiencias neurocognitivas y disfunciones sociocognitivas similares a los pacientes con dependencia de la metanfetamina

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Abstract

Cognitive dysfunction may be a critical aspect of addictive disorders. This study aimed to examine whether individuals with Internet gaming disorder (IGD) have similar neurocognitive dysfunctions and social cognitive impairments as methamphetamine dependence (MD) patients. The participants included 30 individuals with IGD, 30 MD patients and 30 normal controls (NCs). All participants completed the digit span task, Iowa gambling task (IGT), WCST and the Interpersonal Perception Task-15 (IPT-15). The results showed that the IGD and MD groups had lower forwards and backwards scores, choices of advantageous minus disadvantageous decks, mean amount of money earned, number of categories completed, percentage of conceptual level responses, and IPT-15 total and factor scores compared with the NC group. Forwards and backwards scores, number of categories completed, percentage of conceptual level responses, choices from advantageous minus disadvantageous decks and mean amount of money earned were lower in the IGD group than in the MD group. The number of cards chosen from decks A, B, C, and D, total response errors, perseverative errors and failure to maintain set were higher in the IGD and MD groups than in NCs. Total response errors, perseverative errors and failure to maintain set were higher in the IGD than the MD group. The results revealed that neurocognitive deficits and social cognitive dysfunction in IGD are similar to those in MD. From a cognitive perspective, these results supported IGD as an addictive spectrum disorder and might lead to a better assessment of therapeutic efficacy.

Keywords: Internet gaming disorder; Methamphetamine dependence; Neurocognition; Social cognition; Cognition.

Resumen

Las disfunciones cognitivas pueden ser una parte esencial de trastornos de adicción. El objetivo de este estudio fue examinar si las personas con trastorno de juego en Internet (TJI) tienen deficiencias cognitivas y disfunciones sociocognitivas similares a los pacientes con dependencia de la metanfetamina (DM). Los participantes incluyeron 30 personas con TJI, 30 pacientes con DM, y 30 Controles Normales (CN). Todos los participantes completaron la tarea de dígitos, Iowa gambling task (IGT), WCST e Interpersonal Perception Task-15 (IPT-15). Los resultados mostraron que los grupos de TJI y DM obtuvieron puntuaciones más bajas en dígitos directos e inversos, elecciones de barajas favorables menos barajas desfavorables, cuantía media de ganancia monetaria, número de categorías completadas, porcentaje de respuestas a nivel conceptual, y puntuaciones totales y factoriales del IPT-15, comparado con el grupo CN. Las puntuaciones en dígitos directos e inversos, número de categorías completadas, porcentaje de respuestas a nivel conceptual, elecciones de barajas favorables menos barajas desfavorables, y cuantía media de ganancia monetaria eran más bajas en el grupo TJI que en el grupo DM. El número de cartas elegidas de las barajas A, B, C, y D, total de respuestas erróneas, errores perseverativos, e incapacidad para mantenimiento de sets eran más elevados en los grupos TJI y DM que en el grupo CN. El total de respuestas erróneas, errores perseverativos, e incapacidad para mantener los sets eran más elevados en el grupo TJI que en el grupo DM. Los resultados mostraron que las deficiencias neurocognitivas y disfunciones sociocognitivas son similares en los grupos TJI y DM. Desde una perspectiva cognitiva, dichos resultados apoyan la hipótesis del TJI como trastorno del espectro de las adicciones, y podría llevar a una mejor valoración de la eficacia del tratamiento.

Palabras clave: Trastorno de juego en Internet; Dependencia de la metanfetamina; Neurocognición; Cognición social; Cognición.

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Internet addiction disorder (IAD) mainly refers to excessive Internet use that interferes with daily life (Byun et al., 2009). Many studies reported that IAD caused the negative effects on physical and mental health, which led to poor concentration and academic performance, headache, and fatigue, as well as mood disorders, dysfunctional personality, impulsivity, and aggressiveness (De Berardis et al., 2009; Ko, Yen, Liu, Huang, & Yen 2009; Spada, 2014; Dol, 2016;). Previous researchers have reported that IAD is often divided into certain subtypes of addiction including to gaming, online social networking, Internet pornography and Internet shopping (Masters, 2015; Moreno, Jelenchick, Coc, Young &Christakis,, 2011). Until now, there has been debate as to whether IAD is a mental disorder. Because of the lack of consensus regarding the existence of IAD, many scholars have used the terminology "excessive" or "problematic" to denote harmful use of the Internet. A few previous studies have supported IAD as a type of behavioral addiction because there are many similarities between the neurobiology of behavior and substance addiction (Zhou, Yuan, Yao, Li & Cheng, 2010; Zhou, Yuan & Yao, 2012; Zhou, Li & Zhu, 2013). As a subtype of IAD, Internet gaming disorder (IGD) has been included in the American Psychiatric Association's Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), which was issued in May 2013. Although IGD is included in the Emerging Measures and Models (section 3) of the DSM-5, it is not considered a mental disorder. However, Gaming disorder which refers to too much use of the internet, computers and smart phones was included in International Classification of Diseases and Related Health Problems 11th Revision (ICD-11). Because the concept and definition of IGD was shaped by a public health approach, the participation of a broad spectrum of health professionals will be more valid and will have a great impact at different levels of the health care system both in terms of identification and management (Bobes Bascaran, Florez, Seyjo & Bobes Garcia, 2019).

Cognitive functions are defined as the ability to perform mental actions or to acquire knowledge and understanding through thought, experience, and the senses. Within psychology and psychiatry, cognitive function refers to processes such as attention, working memory, judgment, evaluation, reasoning, problem solving, decision making, and comprehension; i.e., it usually refers to an information-processing perspective of an individual's psychological functioning (Olle, 2011). Cognitive dysfunction may be a critical aspect of addictive disorders (Berre & Sullivan, 2016; Sofuoglu, Devito, Walters & Carroll, 2016). The integrated cognitive function characteristics with behavioral features or social aspects for IAD are helpful for its prevention, diagnosis and treatment. In psychology and psychiatry, neurocognition and social cognition are the major branches of cognitive function. Neurocognition is linked to the function of certain areas, including cortical networks in the brain substrate layers of the neurological matrix at the cellular molecular level (Lisdahl, Wright, Medina-Kirchner, Maple & Shollenbarger, 2014; Hunt, 2014; Corigliano et al., 2014); social cognition refers to the ability to analyze and understand social psychological phenomena. Social cognitive processes include the perception and judgment of social stimuli, the effects of social and affective factors and the behavioral and interpersonal consequences of cognitive processes (Uekermann & Daum, 2008).

Neurocognitive deficits are impairments in cognitive function in some cognitive areas and can be tested with neuropsychological tests in clinical practice. For example, the Wisconsin Card Sorting Test (WCST) is a neuropsychological test of the ability to exhibit flexibility in the face of changing schedules of reinforcement (Zhou et al., 2014; Zhou, Zhou & Zhu, 2016). The digit span task (forwards/backwards) from the Wechsler Adult Intelligence Scale has been used to assess the maintenance and manipulation of verbal information in working memory (Zhou et al., 2014; Zhou et al.2016). The Iowa Gambling Task (IGT) has been used to measure decision-making and problem-solving ability (Linnet, Moller, Peterson, Gjedde & Doudet, 2011; Shurman et al., 2005). Social cognitive deficits refer to disabilities in processing and interpreting socioemotional information from the self or others, including disabilities in recognizing important social cues, inferring others' mental states, appraising the social context and process, and interpreting and managing emotions in social situations (Eack et al., 2010). Regarding clinical assessments, the Emotion Evaluation Test (EET) from the Awareness of Social Inference Test (TASIT) has been used to rate social emotional states, including happiness, sadness, fear, disgust, surprise, anger and neutrality (Mcdonald, Flanagan, Rollins & Kinch, 2003). Theory of mind (ToM) has been used to judge and understand others' mental states, i.e., social perceptions (Henry, Cowan, Lee & Sachdev, 2015). Finally, the Interpersonal Perception Task-15 (IPT-15) has been used to measure personal perceptions (Costanzo & Archer, 1993).

Previous studies have reported that some behavioral addictions, such as pathological gambling, pathological kleptomania and pathological shopping, show similarities with substance addictions (Bosc, Fatseas, Alexandre, Alexandre & Auriacombre,2012; Grant, Odlaug & Kim, 2010; Kreitler & Kreitler, 2015). Further studies have indicated that substance use disorders, mainly including alcohol and drugs, are associated with cognitive dysfunction (Hagen et al., 2016). Methamphetamine is a central nervous system stimulant and exists as levomethamphetamine and dextromethamphetamine. Both levomethamphetamine and dextromethamphetamine are neurotoxic and addictive. Methamphetamine is known to have a high addiction liability (i.e., compulsive methamphetamine use) and dependence liability (i.e., occurrence of withdrawal symptoms when methamphetamine use ceases). Methamphetamine dependence (MD) is a serious social and public problem (Karila, Petit, Cottencin & Reynaud, 2010). Heavy recreational use of methamphetamines may have negative consequences including reductions in grey matter volume in several brain regions and adverse changes in markers of metabolic integrity (Krasnova & Cadet, 2009).

Many studies have reported that individuals with IAD present neurocognitive deficits. For example, a previous study investigated whether the self-regulatory failure of IAD individual results from deficits in both inhibitory control and risk taking with losses, and the results suggested that both inhibitory control and reward functions are impaired in IAD individuals (Qi et al., 2016). Another study indicated that individuals with IGD are impaired in some aspects of inhibition and decision-making functions (Yao et al., 2015). Additionally, a previous study investigated the differences in neurocognitive function between individuals with IAD and alcohol dependence (Zhou et al., 2014). In that study, subjects included Internet-addicted individuals, patients with alcohol dependence and normal controls. All subjects performed the Wisconsin Card Sorting Test and digit span task under the same experimental conditions. The results revealed that Internet-addicted individuals share executive dysfunctions and working memory impairments with alcohol-dependent patients.

Methamphetamine is a commonly used psychoactive substance that endangers many adolescents and youth in Asia Pacific countries and in the USA (Zhuang & Chen, 2016; Courtney & Ray, 2014). Furthermore, Amphetamine-type stimulants are the second most commonly used class of illicit drugs worldwide (Courtney & Ray, 2014). Compared to other substances, such as cannabis or alcohol, the psychopathological characteristics of MD may be considered to represent those of psychoactive substances. Determining whether cognitive dysfunctions in IGD are similar to those in psychoactive substance dependence (such as MD) would be helpful for determining the appropriate mental disorder category of IGD. To understand whether IGD is a mental health disorder, it is essential to compare the cognitive functions of individuals with IGD and with substance dependence. To date, although there has been one study focusing on executive function and working memory of individuals with IGD and alcohol dependence, no studies have compared neurocognitive function and social cognitive function between individuals with IGD and with substance dependence. Neuropsychological tests of neurocognition and social cognition have contributed to our understanding of the effects of IGD on cognitive function. Comparing neurocognition and social cognition between those with IGD and with substance dependence could not only help guide decisions on whether IGD should be considered a type of mental disorder but could also play an important role in investigations of the neurobiological mechanisms of IGD. In the present study, participants included individuals with IGD, MD patients and normal controls (NCs). All participants were measured with the WCST, the digit span task, IGT and IPT-15. The purpose of this study was to examine whether individuals with IGD share similar neurocognitive dysfunction and social cognitive impairments as MD patients.

Materials and methods

Time and setting

The experiment was conducted in the Department of Psychiatry at Wuxi Mental Health Center of Nanjing Medical University, China, from May 2014 to March 2018.

Participants

IGD group.

The diagnostic criteria of the IGD group included the following: a) were aged ≥18 years old; b) met the IGD criteria of the DSM-5; c) did not meet the criteria of any DSM-5 axis I disorder or personality disorder based on the Structured Clinical Interview for DSM-5 (SCID-5) (First, 2015) (Chinese version, which were translated into Chinese by authors of this study), which is a semi-structured interview guide for making the major DSM-5 diagnoses and it is administered by a clinician or trained mental health professional who is familiar with the DSM-5 classification and diagnostic criteria; d) were not smokers; and e) had no diagnosed alcohol or substance dependence(i.e., MD or other consumed drugs), neurological disorder, or any type of head injury or systemic disease that might affect the central nervous system. The IGD group was recruited from Wuxi Mental Health Center. Thirty subjects were recruited into the IGD group.

MD group.

The diagnostic criteria of the MD group included the following: a) were aged ≥18 years old; b) met the criteria of the DSM-5 for methamphetamine dependence; c) had cumulative intravenous methamphetamine use of over 50.0 g; d) did not suffer from significant medical or neurological illnesses; e) were not smokers; and f) did not meet the criteria of any DSM-5 axis I disorder or personality disorder based on a structured clinical interview (Chinese version). All MD patients were in-patients at Wuxi Compulsory Isolated Detoxification Center, and they were all voluntary detoxification patients.

Normal Control (NC) group.

NCs were selected from citizens lived in Wuxi city, Jiangsu Province, China, and were recruited through local advertisements. NCs were excluded from the study if they were smokers or had a diagnosis of alcohol or substance dependence, neurological disorder, or any type of head injury or systemic disease that might affect the central nervous system. Thirty healthy subjects were recruited as NCs. Based on a previous IAD study (Zhou, Li &Zhu, 2013), we chose NCs who spent less than 2 h/day on the Internet. NCs were tested with the YDQ criteria modified by Beard and Wolf to confirm that they were not suffering from IAD.

Diagnostic instruments

The duration of the IGD was confirmed via a retrospective diagnosis. Subjects were asked to recall their life styles when they were initially addicted to the Internet. To confirm that they were suffering from Internet addiction, we re-tested participants with the IGD criteria of the DSM-5. The reliability of the self-reported information provided by IGD subjects was confirmed by talking with their parents on the telephone. Individuals with IGD spent 11.50±2.10 h/day on online activities (including only gaming). The number of days of Internet use per week was 6.32±0.60.

All MD patients were determined by conducting urine screening. The total cumulative dose data were collected through a retrospective MD use report of MD patients, and abstinence period was confirmed by conducting urine screening. Thirty patients were recruited into the MD group, and all MD patients used the drug intravenously only. All MD patients did not consume other drugs. Additionally, all MD patients spent less than 2 h/day on the Internet and were tested with the Young's diagnostic questionnaire for Internet addiction (YDQ) criteria modified by Beard and Wolf to confirm that they were not suffering from IAD (Beard & Wolf, 2001).

Because both the use of methamphetamines for MD patients and the use of online games for IGD patients might affect performance on the tasks administered, we recruited MD patients and IGD patients who had been abstinent from this use as study subjects. At the start of the experiments, a psychiatric resident gathered clinical information on the samples. Their mood state were assessed with the Hamilton Depression Scale (HAMD, 17-item version) (Bech et al., 2010), which is used to measure the severity of depressive symptoms in participants, as well as Hamilton Anxiety Scale (HAMA) (Maier, Buller, Philipp & Heuser, 1988), which is used to measure the severity of anxious symptoms in participants. All participants received a written informed consent form, were paid $31.75, and provided their own written informed consent to participate in this study. The Ethics Committee of Wuxi Mental Health Center of Nanjing Medical University, China, approved the protocol for the research project.

The demographic and clinical characteristics of the participants are provided in Table 1.

Neuropsychological tests

Neurocognition tasks.

Digit span task.

The Wechsler Adult Intelligence Scale-Revised China (WAIS-RC, computerized version), as described in detail previously (Zhou et al., 2014), was used to perform the digit span task. In this task, the participants were told to listen to a series of numbers and to then repeat the numbers in the same order. The first series was three numbers. Each number was said in a monotone voice, one second apart. The participant then repeated the same numbers back to the test administrator. The next step was a series of four numbers, which the participant then repeated back. Similarly, the series of numbers was increased to five and the participants repeated those numbers again. In this study, two main factors were used for the analysis: ① forwards scores and ② backwards scores.

Table 1. *Demographic and clinical characteristics of participants.*

	IGD (n = 30)	DM (n = 30)	Controls	Test statistic
Sex ratio (M/F, %)	53.3/46.7	43.3/56.7	30 (14/16)	χ^2 = 8.59. *p* = .42. NS
Mean age (SD)	22 (5)	22 (6)	22 (6)	*F* (2.89) = 24.06. *p* = .87. η^2 = 0.001; NS
Age range	18 - 27	18 - 27	18 - 27	-
Education (SD)	9 (3)	9 (3)	9 (3)	*F* (2.89) = .34. *p* = .85. η^2 = 0.001; NS
Addiction/dependence duration (month, SD)	34.5 (12.5)	40.7 (12.6)	-	-
Intravenous use	-	100%	-	-
Total cumulative dose (g)	-	286 (231)	-	-
Average daily dose (g)	-	0.59 (0.40)	-	-
Abstinent period (days)	3 (4)	3 (3)	-	-
HAMD (SD)	13.3 (4.2)	14.0 (3.3)	6.7 (2.4)	*F* (2.89) = 15.60. *p* = .029. η^2 = 0.15; IGD and MD › Controls; IGD vs. MD. NS
HAMD (SD)	26.2 (4.6)	27.0 (4.5)	6.9 (3.4)	*F* (2.89) = 10.41. *p* = .037. η^2 = 0.18; IGD and MD › Controls; IGD vs. MD. NS

Note. IGD: Internet gaming addition disorder group. MD: Methamphetamine dependence group. M: male. F: female. SD: standard deviation. HAMA: Hamilton Anxiety Scale. HAMD: Hamilton Depression Scale. NS: not significant.

IGT.

The IGT (computerized version), based on Shurman et al. and as previously described in detail (Shurman et al,, 2005), was used to measure decision making. In this test, subjects are informed that they will be making a series of selections from four decks of cards. They are allowed to switch from deck to deck as often as they want, and the overall goal of the task is to maximize profit on a loan of $ 2000 of "play money." After turning each card, the subject receives a certain amount of money. However, on some cards, the subject not only receives money but also pays a penalty. Specifically, turning any card from deck A or B yields $ 100, and turning any card from deck C or deck D yields $ 50. In deck A, the penalties are frequent and range from $ 100 to $ 350, while in deck B, the penalties are infrequent but are larger in magnitude ($ 1250). By picking preferentially from decks A and B, participants will incur a net loss over time. In deck C, the penalties are frequent and range from $ 25 to $ 75, while in deck D, the penalties are infrequent but of larger magnitude ($ 250). By picking preferentially from decks C and D, subjects will receive a net gain over time. In our study, choices of advantageous minus those from disadvantageous decks, mean amount of money earned, and number of cards chosen from decks A, B, C, and D were used for analysis.

Wisconsin card sorting test.

The WCST (computerized version VI), as previously described in detail (Zhou et al., 2014), was used to measure executive function. This task entails matching stimulus cards with one of four category cards; the stimuli are multidimensional according to color, shape, and number, and each dimension determines a sorting rule. By trial and error, the participant has to determine the preordained sorting rule based on only the feedback on the screen after each sort. After 10 consecutive correct sorts, the rule changes. The participant receives up to six attempts to derive a rule, providing five rule shifts in the following sequence (color – shape – number – color – shape number); each rule attainment was referred to as "completing a category." The assessment continued until all 128 cards were sorted, regardless of whether the participant had determined all the rule shifts. In our study, five main types of results of the WCST were used for the analysis: ① total response errors; ② percentage of conceptual level responses; ③ perseverative errors; ④ number of categories completed; and ⑤ failure to maintain set.

Social cognition task.

IPT-15.

The IPT-15 consists of a 20 - minute video of 15 naturalistic scenes, including one to four roles in each scene. The scenes last from 28 to 122 seconds. In each scene, there is a correct answer to a question about a role played in the scene. The scenes were edited into Chinese. Five different types of scenes were sampled on topics including kinship, intimacy, deception, competition, and status, with three scenes in each area. All participants were told to make assessments about the roles in the scenes. No additional description was given regarding the audiovisual conditions. All participants chose from two or three alternatives for each scene on a standardized answer sheet. The IPT-15 was dubbed into Chinese by a professional dubbing company.

Statistical analysis

Data were calculated and analyzed using SPSS (SPSS, Chicago, IL, USA). The sex ratio of the IGD group, MD group and controls was analyzed with χ^2 tests. One-way analysis of variance (ANOVA) was used to compare the HAMA and HAMD scores, age, education years, digit span task scores, IGT scores and WSCT results between the IGD, MD and Control group. Least square difference (LSD) tests were performed as post hoc analyses when indicated. Partial eta squared (η^2) was used as the reporting measure of effect size for significant effects. Statistical significance was defined as $P < 0.05$.

Results

Comparisons of digit span task scores in the IGD group, MD group and Controls

One-way ANOVA of the forwards and backwards scores revealed a significant main effect of Group (IGD group, MD group and Controls). The forwards and backwards scores of the IGD group and MD group were significantly lower than those of Controls (for forwards scores, $p = .015$ and $p = .018$; for backwards scores, $p = .016$ and $p = .030$), while the above two factors were significantly lower in the IGD group than in the MD group (for forwards scores, $p = .021$; for backwards scores, $p = .026$) (Table 2).

Table 2. *Digit span scores (mean (SD)) in IGD group (n = 30), MD group (n = 30) and Controls (n = 30).*

Variable	IGD	MD	Controls	Test statistic
Forwards scores	8.5 (2.1) *♀	10.0 (1.8) *	13.3 (1.8)	F (2.89) = 13.20. p = .019. η^2 = 0.89
Backwards scores	8.3 (2.6) *♀	10.1 (2.1) *	12.4 (2.3)	F (2.89) = 4.59. p = .027. η^2 = 0.68

Note. IGD: Internet game addition disorder group. MD: Methamphetamine dependence group. SD: standard deviation. *Compared IGD group and MD group to Controls, p ‹ 0.05; ♀Compared IGD group toMD group, p‹ 0.05.

Comparisons of IGT scores in the IGD group, MD group and Controls

One-way ANOVA of participants' choices from advantageous minus those from disadvantageous decks, the mean amount of money earned, and the number of cards chosen from decks A, B, C, and D showed a significant main effect of Group (IGD, MD and Control group). Choices from the advantageous minus disadvantageous decks and the mean amount of money earned in the IGD and MD groups were significantly lower than those of Controls; the number of cards chosen from decks A and B was significantly higher in the IGD and MD groups than in Controls; and the number of cards chosen from decks C and D in the IGD and MD groups was significantly lower than that of Controls(-for choices from advantageous minus disadvantageous decks, p = .001 and p = .029; for mean amount of money earned, p = .043 and p = .045; for number of cards chosen from deck A, p = .019 and p = .036; for number of cards chosen from deck B, p = .040 and p = .046; for number of cards chosen from deck C, p = .028 and p = .031; for number of cards chosen from deck D, p = .043 and p = .047).

Choices from the advantageous minus disadvantageous decks and the mean amount of money earned were significantly lower in the IGD group than in the MD group (p = .001 and p = .025); the number of cards chosen from decks A and B in the IGD group was significantly higher than that of the MD group; and the number of cards chosen from decks C and D in the IGD group were significantly lower than that of the MD group (p = .035, p = .040, p = .042 and p = .041) (Table 3).

Comparisons of WCST scores in the IGD group, MD group and Controls

One-way ANOVA of total response errors, percentage of conceptual level responses, perseverative errors, number of categories completed and failure to maintain set showed a significant main effect of Group (IGD, MD and Control group). Total response errors, perseverative errors and failure to maintain set were significantly higher in the IGD group and MD group than in Controls, and the number of categories completed and percentage of conceptual level responses in the IGD group and MD group were significantly lower than those of Controls (for total response errors, p = .031 and p = .022; for perseverative errors, p = .033 and p = .039; for failure to maintain set, p = .020 and p = .028; for the number of categories completed, p = .041 and p = .033; for percentage of conceptual level responses, p = .013 and p = .018).

Total response errors, perseverative errors and failure to maintain set were significantly higher in the IGD group than in the MD group (p = .024, p = .031 and p = .025), and the number of categories completed and percentage of conceptual level responses of the IGD group were significantly lower than those of the MD group (p = .035 and p = .039, respectively) (Table 4).

Table 3. *IGT scores (mean (SD)) in the IGD (n = 30), MD (n = 30) and Control group (n = 30).*

Variable	IGD	MD	Controls	Test statistic
Choices from advantageous minus disadvantageous decks	12.1 (11.6) *♀	25.0 (14.2) *	32.6 (16.0)	F (2.89) = 33.08. p = .001. η^2 = 1.84
Mean amount of money earned	1917.8 (431.0) *♀	2102.1 (452.3) *	2208.2 (483.1)	F (2.89) = 7.18. p = .039. η^2 = 0.70
Number of cards chosen from deck A	19.6 (5.2) *♀	17.8 (5.1) *	15.5 (3.0)	F (2.89) = 14.29. p = .025. η^2 = 1.15
Number of cards chosen from deck B	25.5 (6.4) *♀	22.1(3.3) *	19.5 (5.2)	F (2.89) = 11.30. p = .018. η^2 = 1.30
Number of cards chosen from deck C	25.2 (6.4) *♀	28.3 (5.7) *	33.0 (6.1)	F (2.89) = 4.25. p = .023. η^2 = 1.28
Number of cards chosen from deck D	27.9 (7.2) *♀	29.3 (5.0) *	32.8 (7.3)	F (2.89) = 4.12. p = .024. η^2 = 1.29

Note. IGD: Internet game addition disorder group. MD: Methamphetamine dependence group. SD: standard deviation. *Compared IGD group and MD group to Controls, p‹ 0.05; ♀Compared IGD group toMD group, p ‹ 0.05.

Table 4. *WCST data (mean (SD)) in the IGD group (n = 30), MD group (n = 30) and Controls (n = 30).*

Variable	IGD	MD	Controls	Test statistic
Total response errors	36.0 (11. 1) *♀	25.3 (12.0) *	17.9 (18.2)	F (2.89) = 23.38. p = .001. η^2 = 1.45
Percentage ofconceptual level responses (%)	50.1 (7.4) *♀	57.9 (7.5) *	62.5 (8.0)	F (2.89) = 6.56. p = .040. η^2 = 0.76
Perseverative errors	23.3 (11.6) *♀	16.8 (12.1) *	12.9 (10.1)	F (2.89) = 16.30. p = .001. η^2 = 1.21
Number of categories completed	5.6 (2.3) *♀	6.2 (3.0) *	6.7 (3.0)	F (2.89) = 10.31. p = .001. η^2 = 1.34
Failure to maintain set	0.8 (0.5) *♀	0.6 (0.7) *	0.4 (0.2)	F (2.89) = 4.10. p = .012. η^2 = 1.20

Note. IGD: Internet game addition disorder group. MD: Methamphetamine dependence group. SD: standard deviation. *Compared IGD group and MD group to Controls, p‹ 0.05; ♀Compared IGD group to MD group, p‹ 0.05.

Comparisons of IPT-15 scores in the IGD group, MD group and Controls

One-way ANOVA of kinship, intimacy, deception, competition, status and total scores of the IPT-15 revealed a significant main effect of Group (IGD group, MD group and Controls). The scores of the five factors mentioned above and total scores were significantly lower in the IGD group and MD group than in Controls (p = .019, p = .013, p = .024, p = .015, p = .036 and p = .011, respectively) but did not differ between the IGD group and MD group (all p> .05) (Table 5).

Table 5. *IPT-15 data (mean (SD)) in the IGD group (n = 30), MD group (n = 30) and Controls (n = 30).*

Variable	IGD	MD	Controls	Test statistic
Kinship	1.5 (0.9) *	1.6 (0.9)	2.5 (0.9)	F (2.89) = 11.68. $p < .001$. $\eta^2 = 1.27$
Intimacy	1.6 (0.9) *	1.6 (0.6)	2.3 (0.7)	F (2.89) = 14.88. $p < .001$. $\eta^2 = 1.15$
Deception	1.4 (0.8) *	1.3 (0.9)	2.5 (0.7)	F (2.89) = 16.54. $p < .001$. $\eta^2 = 1.14$
Competition	1.7 (0.8) *	1.7 (0.7)	2.4 (0.9)	F (2.89) = 19.10. $p < .001$. $\eta^2 = 1.40$
Status	1.3 (0.6) *	1.4 (0.8)	2.3 (0.7)	F (2.89) = 17.64. $p < .001$. $\eta^2 = 1.35$
Total scores	7.3 (2.0) *	7.4 (2.7)	12.0 (2.3)	F (2.89) = 29.66. $p < .001$. $\eta^2 = 1.63$

Note. IGD: Internet game addition disorder group. MD: Methamphetamine dependence group. SD: standard deviation
*Compared IGD group and MD group to Controls, $p < 0.05$.

Discussion

This study is the first to test neurocognitive function and social cognitive function while including working memory, decision making, executive function and personal perception between individuals with internet gaming disorder and patients with methamphetamine dependence. In this research, working memory was assessed with the digit span task, decision making with the IGT, executive function with the WCST, and personal perceptions with the IPT-15. This study indicated that both individuals with IGD and patients with MD exhibited working memory impairments, decision-making dysfunction, executive defects and limitations in personal perceptions and that the neurocognitive and social cognitive impairments of individuals with IGD were similar to those of patients with MD.

Cognitive dysfunctions are commonly observed in individuals with psychiatric and addictive disorders. Because cognitive impairments are similar in addictive and other psychiatric disorders, improvements in cognitive impairments have been proposed as a viable treatment target. IGD is currently not included as a type of mental disorder in the DSM-5 diagnostic system because of the lack of adequate research data. To determine the neurobiological bases of IGD, many neurocognitive and neuroimaging studies have been conducted in the past decade. These studies have indicated that on the neural circuitry level, IGD leads to neuroadaptation and structural changes, and on the behavioral level, IGD presents cognitive dysfunctions in some domains (Kuss & Griffiths, 2011). For example, one study examined resting-state functional connectivity of the insula and its association with Internet gaming characteristics in individuals with IGD and controls, and the results showed that individuals with IGD present significantly stronger resting-state functional connectivity between the posterior insula and postcentral gyrus, precentral gyrus, supplemental motor area, and superior temporal gyrus (Zhang et al., 2015). Another study investigated the changes in functional and structural connections within the salience network in IGD patients using resting-state functional connectivity and diffusion tensor imaging tractography approaches, and the results showed the presence of disturbed structural connectivity within the salience network in IGD adolescents; this change may be related to impaired cognitive control (Xing et al., 2014). Additionally, many studies have indicated that both patients with IGD and pathological gambling exhibit not only decreased sensitivity and enhanced reactivity to gaming and gambling cues but also enhanced impulsive choice behaviors and aberrant reward-based learning (Fauth-Bühler & Mann, 2017). A recent study reported that adolescents with IGD were more disturbed by emotional interference and had compromised dorsal anterior cingulate cortex activation based on a Stroop Match-to-Sample task (Lee et al., 2015). In addition, a previous study investigated cognitive biases and executive function involving mental flexibility and response inhibition in IGD (Zhou et al., 2012). In that study, all participants performed the Internet game-shifting task, and the results revealed that IGD presented cognitive biases towards information related to Internet gaming and executive functioning skills (i.e., lower mental flexibility and response inhibition).

In our study, individuals with IGD exhibited not only neurocognitive deficits but also social cognitive dysfunctions. The findings regarding working memory impairment, decision-making dysfunction, and executive deficits are similar to those of previous studies, further suggesting that neurocognitive impairment is a critical factor in IGD. In previous studies, no results on social cognition in IGD patients were reported. Our results on social cognitive impairment increase the understanding of cognitive dysfunction in IGD.

It is well known that methamphetamine dependence is associated with cognitive impairment, and improved cognitive function should thus be considered an important component of treating methamphetamine dependence (Zhong et al., 2016; Morgan et al., 2014). Many studies have indicated that cognitive impairment is a key factor in methamphetamine dependence. For example, one study investigated the differences in brain activation during a risky decision-making task and in resting-state functional connectivity within mesolimbic and executive control circuits between methamphetamine-dependent patients and controls (Kohno, Morales, Ghahremani, Hellemann & London, 2014); the results displayed that methamphetamine-dependent patients presented stronger connections in the ventral striatum but weaker connectivity in the right dorsolateral prefrontal cortex. Furthermore, methamphetamine-dependent patients exhibited greater resting-state functional connectivity of the midbrain with the putamen, amygdala, and hippocampus. Another study investigated whether exposure to methamphetamine-related visual cues elicited craving and/or altered dual task cognitive performance in methamphetamine-dependent patients, and the results showed that methamphetamine-dependent patients had cognitive dysfunctions that were more pronounced during exposure to methamphetamine-related cues (Tolliver et al., 2012).

Patients with methamphetamine dependence exhibited social cognitive dysfunctions. A study applying a facial emotion recognition task and advanced ToM tasks evaluated social cognition in MD patients and found that the performances of MD patients on the facial emotion recognition task and eye test were lower than those of controls; that the performances of MD patients on the WCST were worse than those of controls; and that impairments in cognitive flexibility were correlated with impairments in facial emotion recognition and ToM in MD patients (Kim, Kwon, & Chang, 2011). Another study using facial affect recognition, ToM, executive function and memory investigated social cognitive function in MD patients. The results revealed that MD patients presented impairments in measures of facial affect recognition and ToM and that the magnitudes of these deficits were comparable or larger than those observed on the cognitive measures (Henry, Mazur & Rendell, 2009). In our study, MD patients displayed both neurocognitive deficits and social cognitive dysfunction, and these findings are similar to those of previous studies. From a cognitive perspective, these results supported IGD as an addictive spectrum disorder. These findings also support the importance of cognitive dysfunction as a clinical symptom in MD, and improvements of cognitive dysfunction may be the critical index for the assessment of therapeutic efficacy. Our results propose that the use of cognitive enhancers during abstinence that may promote a drug-free state by reversing cortical dysfunction linked with prolonged MD abuse.

Comparisons of neurocognitive and social cognitive function between IGD and MD are helpful to understand the pathogenesis and etiology of IGD. In this study, individuals with IGD exhibited neurocognitive deficits (working memory impairments, decision-making dysfunctions, executive defects) and social cognitive dysfunctions (personal perception limitations) that were similar to those of patients with MD. Our study suggests that both neurocognitive and social cognitive dysfunction are a consequence of the “addiction”, and cognitive impairment is a predisposing factor for IGD and MD. Regarding the cognitive aspects, our results supported that IGD should be considered an addictive spectrum disorder.

Many previous studies have reported that both IGD and MD patients experience anxiety or depressive symptoms (Kuss & Griffiths, 2011; Zhou et al., 2012; Morgan et al., 2014; Zhong et al., 2016). This finding suggests that anxiety or depressive symptoms are a part of the clinical characteristics of IGD and MD. In our study, although there were significant differences between patient groups (IGD and MD patients) and healthy controls in their scores on measures of anxiety and depression, these findings do not suggest associations with anxiety disorder or depressive disorder. In this study, there were several limitations. First, because only three aspects of neurocognition (working memory, decision making and executive function) and one aspect of social cognition (personal perception) were used to determine that the cognitive function of individuals with IGD was similar to those of patients with MD, this process did not assess overall cognition. Second, the IPT-15 was only dubbed into Chinese by a professional dubbing company and a Chinese version was not developed; therefore, the reliability and validity of the IPT-15 were influenced by social and cultural differences between Chinese and American populations. Finally, the results of this study are preliminary given the small sample size. Further studies with complete Chinese versions of neuropsychological tests and larger sample sizes are needed to replicate these findings.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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